PAPER • OPEN ACCESS

Tests on the tractor installed experimental device for heating the mixture of bioethanol in diesel fuel

To cite this article: B Khakimov *et al* 2023 *IOP Conf. Ser.: Earth Environ. Sci.* **1231** 012017

Tests on the tractor installed experimental device for heating the mixture of bioethanol in diesel fuel

B Khakimov[1], Z Sharipov[1], S Alikulov[1] Z Alimova[2] and E Ganiboyeva[1]

[1]Institute of Irrigation and Agricultural Mechanization Engineers (National research university), 39, Kari Niyaziy str., Tashkent, 100000, Uzbekistan
[2]Tashkent State Transport University, 1, Temiryolchilar Street, Tashkent, 100167, Uzbekistan

E-mail: ganiboyevaergashxon@gmail.com

Abstract. Research and development activities aimed at the development of new scientific and technical bases of resource-saving technologies and mixed fuel preparation devices, which implement the use of alternative fuels to save traditional fuels, are being carried out. On the basis of theoretical and experimental studies, the initial requirements and technical conditions of the device for heating the bioethanol mixture to the diesel fuel and the engine supply system was tested. The fuel mixture prepared by heating the recommended diesel fuel and bioethanol proportioned mixture was tested on the TTZ 80.10 tractor. The tests showed that the specified injection angle of the UTN-5 fuel pump was advanced by 2 degrees, and the injector needle pressure was determined to be 1.4-1.6 MPa.

1. Introduction
In the agricultural production of our country, comprehensive measures are being taken to reduce labor and energy consumption, save natural resources, increase the amount of alternative fuels used in agricultural machinery, develop high-quality liquid alternative fuels and use them as additional fuel in agricultural machinery [1,2 ,3].

2. Materials and methods
Currently, research and development activities aimed at the development of new scientific and technical bases of resource-saving technologies and mixed fuel preparation devices, which implement the use of alternative fuels to save traditional fuels, are being carried out. On the basis of theoretical and experimental researches, heating up a quantitative mixture of bioethanol to diesel fuel, the transfer device (temperature stimulator) to the engine supply system was adapted to be installed on TTZ-80-10, MTZ-80X tractors based on the initial requirements and technical conditions, and for use in the educational workshop of TIIAME, its experience and test samples were prepared and field tests were conducted in the farms of "Tashkent Agroservis MTP" LLC, Upper Chirchik, Saykhunabad district of Syrdarya region and Kamashi district of Kashkadarya region [4,5,6].

Figures 1 and 2 show general and component views of the prototype temperature stimulator. The mixture is heated by the rotating heating liquid in the engine cooling system, and the ready-heated mixture is fed into the high-pressure fuel pump inlet channel of the engine through a pipe equipped with a special filter-pamper that transfers the mixture fuel and traps small mechanical impurities and water droplets on its upper part. A PB-105 12V electric heater designed for special installation and use is installed on the device. A temperature sensor to monitor the temperature of the mixture being heated inside the device can generate water vapor from the bottom of the device and is equipped with a water sensor that warns about drops and a 12V electric valve designed to open and close the heating pipe path according to the internal temperature of the device [7,8,9].

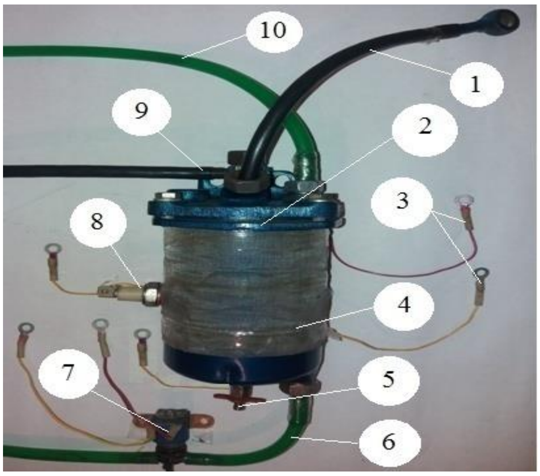

Figure 1. A view of the experimental copy of the temperature stimulator: 1-coarse filter inlet pipe; 2- corps; 3-heater connectors;4-electric heater; 5-spout; 6- heating liquid inlet pipe; 7-heating fluid control valve; 8-mixed temperature sensor; 9-pipe connecting to the low-pressure pump; 10- heating fluid outlet pipe.

In accordance with the instructions of the above-mentioned temperature sensor, the control of the operation of the sensor for opening or closing the hot water path, the temperature sensor, and the density meter sensors is loaded into the memory of the automatic control unit. It is recommended to install the developed device after the coarse filter of the supply system of diesel engines in the interval between the high-pressure fuel pump and the fine filter. Figure 2 shows the disassembled and laboratory prototypes of the developed device.

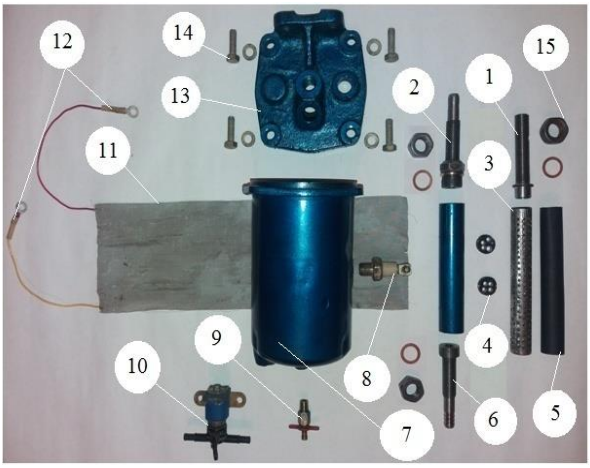

Figure 2. Components of a temperature stimulator: 1-hole pipe fitting; 2,6-upper and lower nozzles; 3-hole pipe; 4-heater plate; 5- filter (pampers); 7- corps; 8-mixed temperature sensor; 9-spout; 10-heating fluid control valve; 11-electric heater; 12-heater connectors; 13-cover; 14 - sealing bolts.

The heating pipe inside the temperature stimulator is divided into 3 equal volumes by 2 hole plates. The heating pipe located inside the temperature stimulator is divided into 3 equal volumes by 2 hole plates inside[11,12,13].

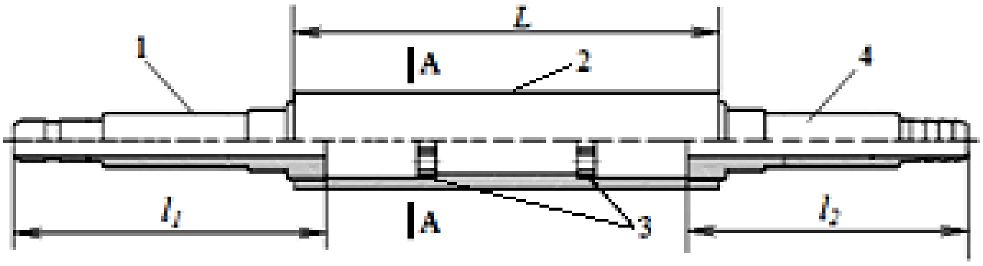

Figure 3. Heat transfer pipe and its parts: 1,4-lower and upper nozzles; 2- heat transfer pipe; 3-hole plates; dP-hole diameter; Dp-plate diameter; Fs-The surface of the perforated part of the plate.

3. Results and discussion

We calculate the mass of the pipe (figure 3) used as a heater (included in the device) by formula (1).

$$m = \rho \cdot V_3 \tag{1}$$

$$V_3 = \pi r_2^2 \cdot L + 2\pi r_2^2 \cdot l - 10 \cdot \pi \cdot r_3^2 \cdot l \tag{2}$$

where r^2 is the radius of the pipe, r3 is the radius of the hole.

$$m = \rho \cdot \pi (r_2^2 \cdot L + 2r_2^2 \cdot l + 10 \cdot r_3^2 \cdot l) \tag{3}$$

To determine the flow rate of the mixture passing through the plate holes installed in the heat pipe, we use the following equation [2]:

$$X = \frac{0{,}785 K_d^2 F_c}{100 l_0 r_T} = \frac{1}{n}\left(\sqrt{n^2 - 1} + \ldots + \sqrt{n^2 - (n^2 - 1)}\right) \tag{4}$$

where: K_d is the diffusion coefficient, F_c is the surface of the perforated part of the plate mounted on the cross section of the pipe.

We find the surface of the perforated part of the plate mounted on the pipe cross-section by the following expression (figure 4):

$$F_c = S_{\text{groove.}} - S_{hole} = \pi R^2 - \pi r^2 = \pi (R^2 - r^2) \tag{5}$$

in which: $S_{groove.}$ – pipe base face, mm^2; $S_{hole.}$ – hole face, mm^2; R – the radius of the pipe base, mm; r – hole radius, mm.

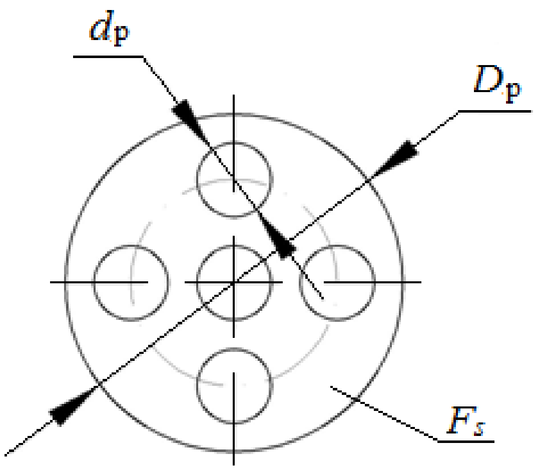

Figure 4. Perforated plate.

The distance between the plate holes is determined from the following expression:

$$\frac{l_0}{n} = c + l \tag{6}$$

in this c – the width of the gap between the side holes, mm [12]. The solution of the equation with respect to the number of holes are presented in table 1.

Table 1. The number of holes in the plate.

n	X	n	X
1	0.000	6	4.093
2	0.866	7	4.887
3	1.688	8	5.679
4	2.498	9	6.471
5	3.296	10	7.257

From table 1, we can see that the increase in the number of holes in the plate determines the performance of the device. In this case, the resistance of the plate and the number of holes, in turn, are of primary importance. The dependence of permeability on plate resistance and the number of holes is determined by the following formula:

$$\Delta P_\Gamma = \xi_{Tp} \frac{l}{d_э} \cdot \frac{\vartheta^2 \gamma}{2g} \tag{7}$$

in this ΔP_Γ – plate resistance, ξ_{Tp} – coefficient of friction (calculated for spans or holes), $d_э$ – equivalent diameter of the plate [14,15,16].

Based on the above analyzes and the results of the solution of expression (7), the dependence of the following permeability on the number of plate holes graph was constructed.

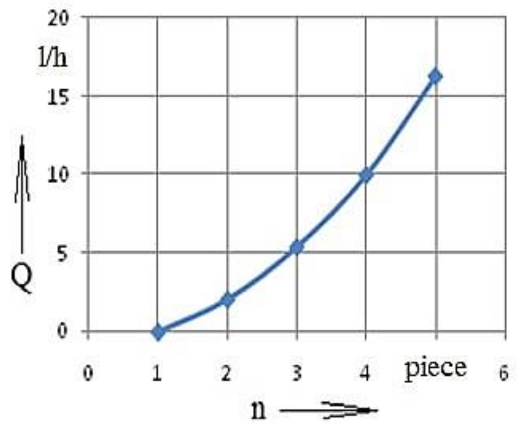

Figure 5. Permeability graph as a function of the number of plate holes.

Analysis of the presented graph shows that the rate of passage of the mixture passing through the holes of the plate installed in the heat pipe depends on the number of holes. Based on the above-mentioned expressions, conducted studies and information provided in the literature, table 1 presents the parameters of the device elements for preparing bioethanol mixed fuel [5,6].

Table 2. Parameters of the device for reheating the developed diesel fuel and bioethanol quantitative mixture.

No	Naming of indicators	Designation	Value
1.	Height of heat transfer device, mm	L	150
2.	Diameter of heat transfer device, mm	D	100
3.	Diameter of the cover connecting the device	D_c	105

	elements, mm		
4.	Total volume of the device, mm3	V	$1,2\cdot10^6$
5.	Heater pipe height, mm	L_h	140
6.	Heater pipe diameters, mm	d	20
7.	The height and inner diameters of the inlet and outlet nozzles of the heater, mm	l_n ;d_n	80; 8
8.	Diameters of suspension plates installed in the heater pipe, mm	d_1;d_2	18; 18
9.	Number of hanging holes, pcs	n_h	10
10.	Height and diameter of the transmission pipe with a filter element, mm	l_f; d_f	134;15
11.	The number of holes in the filter transmission pipe, pcs	n_f	264
12.	Height and diameter of filter transmission pipe, mm	l ; d	65; 7
13.	Height and diameter of water filter pump, mm	l_p; d_p	135; 16

On the basis of the results of the research, a graph of the change in the pressure of the mixture of diesel fuel and bioethanol obtained through the perforated pipe with filter pampers was constructed.

Figure 6 shows that when the pressure of the mixture is changed from 0.1 mPa to 0.6 mPa, the permeability of the mixture increases rapidly, and when the pressure increases from 0.4 mPa to 0.6 mPa, the permeability of the mixture changes slightly, and at 0.6 mPa remains almost unchanged, which means that the pressure of passing the mixture through the perforated pipe should be from 0.1 mPa to 0.6 mPa [5,6,7,8].

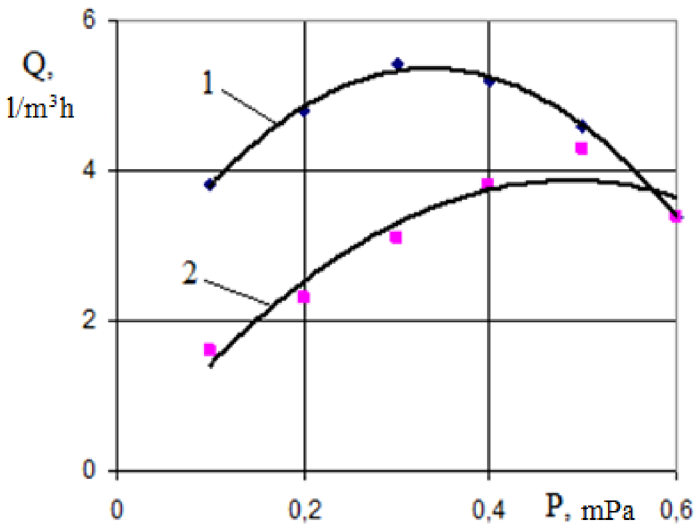

Figure 6. The graph of the change of permeability and selectivity of the mixture depending on the pressure. 1-selectivity; 2-Conductivity.

Based on the results of experimental studies and observations, it can be determined from the graph of the rate of passage of the mixture through the perforated pipe of the device in Figure 7 that with an increase in the passage rate of the mixture by 1-1.5 m/s, the permeability of the mixture doubles and the transfer rate of the mixture is 2-3 m/s. s, and in the interval, the transmission speed increases by 10 percent and then remains unchanged. Based on the above, it was determined that the speed of the mixture flow is around 1-2 m/s [8,9,10].

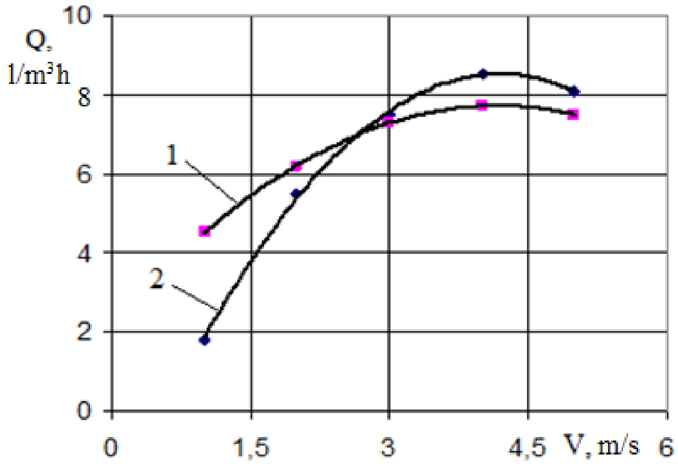

Figure 7. A graph of the change in the velocity of the mixture as it passes through the perforated pipe. 1-theoretical; 2-experimental.

Table 3 shows the laboratory comparative test results of diesel fuel + bioethanol 8% mixture fuel not naturally heated and 12% mixture heated to 86 °C.

Table 3 Diesel fuel, bioethanol and 12% blended fuel comparative characteristics.

No	Indicators	Diesel fuel	don't mix 8%	don't mix 12%
1.	Water content, %	no	traces	traces
2.	Density at 20 °C, kg/m^3	830	826	825
3.	Viscosity at 20 °C, sSt	4.2	3.7	3.4
4.	Flash temperature in a closed crucible, °C	40	33	31
5.	Acidity level, mg KON in 100 ml of fuel	3.3	3.2	3.0
6.	Theoretically, the amount of air for the combustion of 1 kg of fuel	14.91	12.91	13.87
7.	Fractional content (%) evaporation temperature,			
	°C- 50	280	280	280
	- 96	360	350	350
8.	Elemental composition:			
	- carbon	0.87	0.72	0.64
	- hydrogen	0.13	0.13	0.13
	- oxygen	-	0.45	0.47
9.	Corrosion rate of St20 steel, mm/year	0.076	0.091	0.082

The analysis of the table shows that in the 8 percent mixture the acidity level is 3.2, and in the 12 percent mixture fuel heated to 86°C

3.0 m.g of KON. The corrosion rate of St 20 steel is 0.091 in an 8% mixture, and in a 12-phase mixture heated to 86°C it is 0.082 mm/year [12,13,14].

Tests were carried out using diesel fuel + bioethanol 8% mixture at natural atmospheric temperature and 12% mixture temperature stimulant, cooling fluid at temperatures of 85-90 °C with PLN-35 plow aggregate on TTZ 80.10 tractor. From the data of table 4, it can be seen that when the work of the tractor working on ethanol-added fuel and diesel fuel is compared, its useful work coefficient does not decrease, and the tractor TTZ-80-10 aggregated with PLN-35 plow is 3rd when plowing the 88:12 percent mixed soil to a depth of 0.2 m the least fuel was consumed when the transmission worked in the I range [15,16,17].

Table 4. Energy evaluation indicators of TTZ-80-10 tractor aggregated with PLN-35 plow.

No	Naming of indicators	Types of fuel		
		Diesel fuel	92:8 percentage mixture	88:12 percentage mixture
When plowing the soil to a depth of 0.2 m (2 passes/I interval)				
1.	Speed of movement, km/h	8.3	8.2	8.1
2.	Coverage width, m	1.05	1.05	1.05
3.	Processing depth, cm	20	20	20
4.	Extension /span	2/1	2/1	2/1
5.	Fuel consumption, kg/ha	13.2	13.5	13.0
When plowing the soil to a depth of 0.25 m (2 passes/I interval)				
1.	Speed of movement, km/h	7.8	7.6	7.5
2.	Coverage width, m	1.05	1.05	1.05
3.	Processing depth, cm	25	25	25
4.	Extension /span	2/1	2/1	2/1
5.	Fuel consumption, kg/ha	13.6	13.7	13.3
When plowing the soil to a depth of 0.2 m (3 passes/I interval)				
1.	Speed of movement, km/h	9.5	9.6	9.4
2.	Coverage width, m	1.05	1.05	1.05
3.	Processing depth, cm	20	20	20
4.	Extension /span	3/1	3/1	3/1
5.	Fuel consumption, kg/ha	11.0	11.5	10.4
When plowing the soil to a depth of 0.25 m (3 passes/I interval)				
1.	Speed of movement, km/h	8.8	8.5	8.7
2.	Coverage width, m	1.05	1.05	1.05
3.	Processing depth, cm	25	25	25
4.	Extension /span	3/1	3/1	3/1
5.	Fuel consumption, kg/ha	11.4	11.7	10.8

A device for heat transfer of a quantitative mixture of bioethanol to diesel fuel, which can be installed in the fuel supply system of the engine, is proposed, and its general view. It is presented in figure 8.

Figure 8. Installation of diesel fuel and bioethanol liquid heating transfer device in the system.1-rough cleaning filter; 2-low pressure fuel suction pump; 3-high pressure fuel pump; 4-temperature stimulator.

Figure 9. A view of the fuel-liquid heating device installed on the tractor. 1-high pressure pump; 2nd coarse cleaning filter; 3-temperature stimulator.

Figure 9 shows the general views of the installed state on tractors equipped with a device for heating and mixing the proportioned mixture of bioethanol to diesel fuel installed in the supply system with the help of liquid [17,18].

It was proved that the device is suitable for work and gives high efficiency in operational tests conducted in the farms of Kamashi and Saykhunabad districts of Kashkadarya region. For the purpose of research, we mixed bioethanol with a density of 789 kg/m3 and a concentration of 94.7% with diesel fuel in the amount of 12%. To create a quality mixture, it is necessary to heat it to a certain temperature. In tractors, hot water temperature from the engine cooling system was used to heat the mixture.

4.Conclusion

According to the conducted theoretical and experimental studies, the height of the heating transfer device of the quantified mixture of diesel fuel and bioethanol should be 150 mm, the inner diameter should be 100 mm, the outer diameter should be 102 mm, and the working volume should be at least 1.2·106 mm^3.

Stable heating of the diesel and bioethanol mixture is achieved by changing the number and distance between the perforated plates inside the heater tube, and this distance is in the range of 40-50 mm, and the number of plates is 2 pieces. It can be concluded from the results of the experiments obtained at the laboratory stands that when a mixture of bioethanol is heated and mixed with diesel fuel and used as a fuel, a complete combustion process was observed in the engine, the amount of harmful gases released into the atmosphere decreased, the engine power increased and the main performance indicators were improved.

The fuel mixture prepared by heating the recommended diesel fuel and bioethanol proportioned mixture was tested on the TTZ 80.10 tractor. During the test, the following instructions were given: the specified injection angle of the UTN-5 fuel pump on the D-243 engine installed on the TTZ 80.10 tractor was advanced by 2 degrees, and the injector needle pressure was determined to be 1.4-1.6 MPa.

References

[1] Grekhov P V, Markov V A and Ivashchenko N A 2004 *Fuel equipment and diesel control systems* (Moscow)
[2] Khakimov B B and Salimov O U 2018 Ways to increase the dispersion of atomization of a multi-component fuel mixture in engine combustion chambers *Agroilm* **2**
[3] Faizullaev E 2005 *The structure and theory of vehicles* (Tashkent)
[4] Khakimov B B and Sharipov Z Sh 2021 A device with rotary apparatus for the production of diesel fuel *Current status and prospects for the development of the technical base of the agro-industrial complex. Dedicated to the memory of Doctor of Technical Sciences, Professor Petr Grigorievich Mudrov*
[5] Fayziev M M 2007 *Internal combustion engines* (Tashkent)
[6] Khakimov B B, Rajabov N Q, Sharipov Z Sh, Kalandarova S T, G'aniboyeva E M and

Kulmamatov O A 2021 *IOP Conf. Series: Earth and Environmental Science* **868** 012022
[7] Belyaviev A V 1998 *Fuel equipment M. Rosagropromizdatstvo of motor transport diesel engines Kadyrov S.M. Internal combustion engines* (Tashkent: Generation of the new century) 2006
[8] Kadyrov S M, Salimov O U and Proskurin A I 2011 *Motors and car theory* (Tashkent)
[9] Khakimov B, Rajabov N, Xaydarov T, Utepov B, Murodov T, Kulmamatov O and Khudoyorov O 2021 Factors for Stability of Compressed Gas Impermeability in Engine Combustion Chambers *Annals of R.S.C.B.* pp 2981-8
[10] Arkhangelsky V M, Wikhert M M, Voinov A N, Stepanov Yu A et al. *Automobile engines* (M .: Mashinostroenie)
[11] Muravsky A V and Fine M A *Fire in harness* (M.: Knowledge)
[12] Latko V, Lukanin V N and Khachiyan A S 2002 *The use of alternative fuels in internal combustion engines* (M.: MADI)
[13] Salimov O U, Imomov Sh J, Khakimov B B and Ganiev B G 2021 *Scientific and technical solutions for creating alternative fuel mixture and using it in diesels* Monograph (Tashkent)
[14] Ganiboyeva E, Norov B, Suyunov S and Khudaev I 2022 *IOP Conf. Ser.: Earth Environ. Sci.* **1076** 012084
[15] Ganiboyeva E, Raxmatullaev J, Sapaeva R, Jumaev Sh and Khasanov A 2022 Theoretical evaluation of the propensity of motor oils to oxidation *Journal of Engineering and Technology(JET)* pp 17-20
[16] Ganiboyeva E, Khakimov B, Shermuxamedov X and Rakhimov Yu 2022 *IOP Conf. Ser.: Earth Environ. Sci.* **1076** 012085
[17] Astanakulov K Shovazov K Borotov A Turdibekov and A Ibrokhimov S 2020 Wheat harvesting by combine with GPS receiver and grain sensor *E3S Web of Conferences* **227** 07001
[18] Babojanov A B, Dulliev A K and Turdibekov A R 2022 *IOP Conference Series: Earth and Environmental Science* **1076(1)** 012071